MC-PAD: CERN, DESY, GSI, JSI, AGH, LNF, NIKHEF, PSI, UHH, Evatronix, IFJ , NIMP, Micron, Photonis

MARIE CURIE INITIAL RESEARCH TRAINING NETWORK

~~ACEOLE~~MC-PAD

FELLOWSHIPS FOR EARLY-STAGE AND EXPERIENCED RESEARCHERS IN ~~DATA ACQUISITION, MICROELECTRONICS AND OPTOELECTRONICS~~THE FIELD OF PARTICLE DETECTORS FOR FUTURE PARTICLE PHYSICS ~~FOR LARGE HADRON COLLIDER~~ EXPERIMENTS

Introduction

The EU-funded 7th Framework Programme has two main strategic objectives; to strengthen the scientific and technological base of European industry and to encourage its international competitiveness, while promoting research that supports EU policies.

As part of this programme, initial training of researchers is~~will~~ being offered through a multi-site Marie-Curie Network~~s~~ which will improve their research skills and help them join established research teams. In parallel, complementary training will enhance their career prospects in both public and private sectors. The network with the acronym MC-PAD (**M**arie **C**urie – **PA**rticle **D**etectors) comprises nine academic participants, three industrial partners and two associated academic partners.

- CERN - European Organization for Nuclear Research (CH)
- DESY - Stiftung Deutsches Elektronen-Synchrotron (DE)
- GSI - Gesellschaft für Schwer-ionenforschung mbH (DE)
- JSI - Jožef Stefan Institute (SI)
- AGH – UST University of Science and Technology (PL)
- LNF - Laboratori Nazionali di Frascati - Istituto Nazionale di Fisica Nucleare (IT)
- NIKHEF - Stichting voor Fundamenteel Onderzoek der Materie (NL)
- PSI - Paul Scherrer Institut (CH)
- UHH - University of Hamburg (DE)

Associated Partners

- Evatronix SA (PL)
- NIMP - National Institute of Materials Physics (RO)
- IFJ PAN - Polish Academy of Sciences (Polska Akademia Nauk) PAN (PL)
- Micron Semiconductor Ltd. (UK)
- Photonis SAS Holding (FR)

MC-PAD, April 2008

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- ~~In parallel, complementary training will enhance their career prospects in both public and private sectors~~

We are therefore looking for young researchers ready to participate in a Marie Curie Initial Training Network (ITN) offering research training in the development and application of advanced particle detectors ~~advanced microelectronics, optoelectronics, networking and real-time data processing technologies in the world's state-of-the-art particle detector systems at the Large Hadron Collider (LHC), and a future upgraded Super-LHC (SLHC).~~

The young researchers will be based for most of their time at one of the participating institutes~~CERN~~, supervised by internationally recognized experts and have access to state-of-the-art equipment. Hands-on project training will be supplemented with formal training courses in relevant and related fields, and a wide variety of complementary training courses, colloquia and seminars. In order to ensure exposure to complementary research and industry environments m~~M~~obility of researchers in the form of detachment to one or more of~~within~~ the ~~ITN~~ other network participants and associated partners is planned and expected for up to 30% of the duration of each fellowship.

~~**will ensure exposure to complementary research and industry environments.**~~

Eligibility conditions

Several FP7 Marie Curie initial research training projects are being offered by CERN and associated partners, predominantly for ***Early-Stage Researchers,*** and also for a smaller number of ***Experienced Researchers,*** who fulfil the following conditions:

- **Early-stage researchers (ESR)** are defined as those in the first four years (full-time equivalent) of their research careers, starting at the date of obtaining the degree which would formally entitle them to embark on a doctorate, either in the country in which the degree was obtained or in the country in which the research training is provided, irrespective of whether or not a doctorate is envisaged.

- **Experienced researchers (ER)** must, at the time of recruitment (i) be in possession of a doctoral degree, independently of the time taken to acquire it, or (ii) have at least four years of full-time equivalent research experience, including the period of research training, after obtaining the degree which formally allowed them to embark on a doctorate in the country in which the degree/diploma was obtained or in the host country (irrespective of whether or not a doctorate was envisaged).

  The research experience of an experienced researcher recruited for initial training may not exceed 5 years at the time of the appointment. An early-stage researcher may not be re-appointed as an experienced researcher.

Applications for the specific research training projects described below are invited from young researchers[1] meeting the above-described eligibility conditions.

Candidates will be selected taking into account their:

- Ability to work in a multidisciplinary team;

- Willingness to travel and communicate in an international, intersectorial environment, and to broaden their experience and skills through complementary training (e.g. languages, management and communication courses, technology transfer and intellectual property issues, etc.);

[1] ~~CERN is an equal opportunity employer. In particular applications are strongly encouraged from female candidates. Candidates of all nationalities (????) are eligible for these Marie Curie Early Stage Researcher and Experienced Researcher fellowships.~~

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- Proficiency in English, which is the official languages of the network. For fellows based at CERN: a good knowledge of English or French is required, as well as a basic knowledge of the other language or an undertaking to acquire it rapidly.

Overview of the research training projects~~Workpackage description (example: WP 4)~~

Early-stage and Experienced Researcher fellowships are available in the following areas:

- radiation tolerant silicon detectors,
- gaseous detectors,
- calorimetry,
- photon detection and particle identification,
- monolithic detectors and front-end electronics,
- simulation tools.

~~five work packages:~~

~~*1. Pixel detector systems for particle tracking and imaging*~~

~~Hybrid pixel detectors are developed for high-precision measurement of particle tracks in the LHC and other experiments. Through the *Medipix Collaboration*, this pixel technology is being transferred to other domains, such as medical imaging, materials analysis, computed tomography, X-ray crystallography and imaging in astronomy. Key challenges are the reduction of the thickness of the detector material (because the material distorts the physics interactions) and developing low-cost interconnection techniques to construct affordable, large area hybrid pixel arrays. Advances in industry-based ultra-high density interconnect and assembly technology will be investigated in order to address these challenges.~~

~~*2. ASIC building blocks for detector readout systems*~~

~~A set of robust ASIC building blocks and functions needs to be developed to meet the requirements of front-end electronics and detector readout systems for future new experiments or upgrades of existing detectors. The project will be to specify, design, characterize and qualify one or more low-power, ASIC building blocks or functions in 130nm CMOS technology. Characterization will involve measurement of tolerance to total dose and single event phenomena.~~

~~*3. Power management for on-detector electronics*~~

~~Special attention has to be paid in the development of particle tracking detectors to minimize the amount of material. Reduction of front-end electronics power dissipation and efficient on-detector power distribution schemes will be essential to limit the amount of material in the form of cabling and cooling infrastructures. Two main approaches are considered for more efficient methods of delivering power to the on-detector electronics: one consists in exploring *DC-DC conversion* to bring higher voltages and lower currents inside the tracker volume, and the other in exploring *serial powering* schemes. These issues will be explored in the context of a development of new prototype module for an upgraded ATLAS central silicon tracker detector.~~

~~*4. Optical Transmission Systems for SLHC Experiments*~~

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~~The *versatile bi-directional digital link* project aims at developing a radiation tolerant, multi-Gigabit/s optoelectronic data transmission link suitable for several distinct functions in the upgraded SLHC detector. In the past specific data transmission links have been developed by the different experiments for data acquisition, for the broadcast of the system clock and first-level trigger information to the front-end electronics, and for detector control and monitoring functions. The project will develop a general purpose optical link which can cover the three data transmission applications described above for all experiments.~~

~~*5. Data Acquisition Systems for the LHC experiments*~~

~~Real-time event data collection and filtering at the LHC experiments is achieved by large-scale high-performance distributed data acquisition (DAQ) fabrics built with commercial components, including computing nodes, network interfaces, data switches, and network storage systems. These systems consist of thousands of computing nodes and use switching fabrics handling several hundred Gbps sustained data traffic. At a future upgrade of the LHC the DAQ system will have to provide multi-Terabit bandwidths. The projects will involve the initial ramp-up of the LHC DAQ systems; performance optimization of the switching networks and the network storage systems, including the introduction of fault-tolerance at different levels; and the evaluation of next-generation multi-10Gbps network standards for SLHC data acquisition and the construction of demonstrator systems.~~

Detailed job descriptions

1. Radiation Tolerant Mini-strip Tracking Detectors

We address the issues of radiation tolerance paired with high rate capability and high occupancy relevant for the SLHC as well as several FAIR experiments. The CERN based ESR will study radiation damage as well as signal deterioration in close contact with P3, the GSI based ESR will focus upon system aspects, system integration and robust detector operation. This includes the detailed investigation of the deterioration of the signal shape. The considerable difference in radiation fields of the SLHC as compared to FAIR as well as differences in the timing scheme and signal intensities make this project particularly challenging and interesting.

No. early-stage researchers:	2
Work place	CERN or GSI
Contract duration:	36 months
Application deadline:	1 June 2008
Approx. contract start:	1 October 2008
Associated partner(s):	Micron, NIMP, JSI, UHH

The ESR at CERN will design and build a characterization set-up for silicon mini-strip sensors allowing for measurements with a laser (TCT - Transient Charge Technique) and a beta-source (CCE – Charge Collection Efficiency). Irradiated mini-strip detectors made from various silicon materials (n- and p-type FZ, DOFZ, EPI, MCZ) will be investigated. Additionally to the network training, the ESR will receive specific training on silicon detector technology at CERN and GSI, work at GSI for 2 months and stay at the company Micron for 2 weeks.

The ESR at GSI will build a detector module test setup with a complete DAQ system that allows to study the performance of an integrated Silicon detector module. A first detector module will be

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prepared and studied realizing single sided detector readout. This module will then be developed towards a double sided detector readout module and the final module will be fully characterized. The ESR will receive specific training on silicon detector technology at CERN and GSI as well as training on the particularly complicated system integration challenges.

...

1. Pixel detector systems for particle tracking and imaging

An early stage researcher:
In the framework of the CERN R&D in interconnect technologies the researcher will be introduced to the issue of high speed low noise tracking in High Energy Physics experiments with some emphasis on the requirements of the SLHC. A key component to finding appropriate technical solutions to the challenges of tracking at SLHC is to understand the state of the art in packaging technology. This aspect of the training will be acquired during some extended periods at VTT Information Systems in Espoo, Finland. It is expected that this knowledge will lead to the development of new approaches to pixel detector systems at future HEP experiments. Those approaches will be tested on existing CMOS wafers leading to new solutions suitable for particle physics experiments and related applications.

No. early stage researchers: 1
Contract duration: 36 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner(s): VTT Information Systems, Espoo, Finland

An experienced researcher:
In collaboration with the CERN Medipix team the researcher will develop experimental techniques and setups capable of characterizing pixel detector systems covering small and large surface areas. Such systems may be based on silicon sensor material or other high-Z materials. The goal will be the development of new experimental techniques appropriate to X-ray diffraction and imaging. Initial training in materials analysis will take place at PANalytical, Almelo, the Netherlands. Training in single photon counting techniques will take place mainly in the practical environment of the laboratory at CERN. Results are expected to be presented at collaboration meetings and at international symposia.

No. experienced researchers: 1
Contract duration: 18 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner(s): PANalytical B.V., Almelo, Netherlands

2. ASIC building blocks for detector readout systems

An early stage researcher:
Modern microelectronics CAD tools and mixed-signal, semi-custom and full-custom VLSI design methods will be applied with 130nm CMOS technology in order to develop a radiation tolerant Phase-Locked Loop (PLL) with very low phase noise characteristics. The device will be part of a future Timing Trigger and Control system for SLHC and other experiments and will be used among other applications to drive high-speed serializers, high precision digital-to-analogue converters and high resolution time-to-digital converters. This project requires expertise in both the digital and analogue

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circuit design domains and aims at the close integration of both types of circuits in a single ASIC. The work also contains a strong practical component on the domain of characterization and qualification of ASICs for radiation tolerance (total dose) and immunity to Single Event Upsets.

No. early-stage researchers: 1
Contract duration: 36 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: Unit of Telecommunications, INESC Porto (Portugal)

3. Power management for on-detector electronics

The development of a future upgrade of the ATLAS Inner Tracker will involve R&D on advanced techniques for tracking detectors based on silicon strip detector technology and low-power mixed-signal radiation hardened ASICs, including power management blocks and integration at the level of detector modules. The major research goals in which the researcher will be involved are:

- Specification and design of radiation-hardened ASIC building blocks for an upgraded front-end readout circuit for the ATLAS tracker (SCT) in 130 nm CMOS technology;
- evaluation of performance and radiation hardness of prototype building blocks;
- integration and evaluation of the developed building blocks in the ATLAS Inner Tracker Upgrade system.

No. early-stage researchers: 1
Contract duration: 36 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: AGH, University of Science and Technology
Faculty of Physics and Applied Computer Science
Krakow, Poland

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4. Optical Transmission Systems for SLHC Experiments (example: WP 4.1 Experienced Researcher)

4.1 Network architectures for particle physics applications

An early stage researcher:
Under guidance of [*In close collaboration with*] an Experienced Researcher and in collaboration with a small team of specialists, contribute to the development of data read-out and timing distribution systems for future high energy physics experiments, based on Point to Point (P2P) and Passive Optical Network (PON) standards. Develop simplified PON protocols adapted to future bidirectional timing trigger and control distribution systems. Perform simulations and build prototypes, develop test procedures and tools. Assemble PON demonstrators based first on commercial devices and later on components customized for high energy physics applications. Test the demonstrators, analyze the results and present them.

No. early stage researchers: 1
Contract duration: 36 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: Dept. of Electronic & Electrical Engineering, University College, London

An experienced researcher:
In collaboration with a small team of specialists, get familiar with architectures of existing data read-out and timing distribution systems in high energy physics experiments. Understand with experts the requirements of future bidirectional timing trigger and control distribution systems. Draft generic high-level specifications of such systems and evaluate the potential of Passive Optical Networks (PONs) to meet these specifications. Assess the feasibility of implementing simplified PON protocols for future high energy physics experiments and propose a realization model. Carry out simulations, propose project with schedule and milestones and train an ESR to carry it out.
No. experienced researchers: 1
Contract duration: 6 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: Dept. of Electronic & Electrical Engineering, University College, London

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4.2 Characterization of semiconductor lasers:

An experienced researcher:
In collaboration with a small team of specialists, characterize the electrical properties of various packaged semiconductor lasers and carry out measurements of the reflection coefficient of the devices. Obtain electrical circuit models for the laser diodes and through optimization using the measured data, extract the parameters for the equivalent circuit model as simply and accurately as possible. In collaboration with ASIC designers, simulate laser-driver plus laser assemblies and develop simple impedance matching networks to optimize their high bit rate performance. Build hardware prototypes and demonstrate the effectiveness of the proposed matching scheme. This project will require the researcher to spend a significant fraction of the duration of the contract working in a team located at the associated partner INESC, Porto, Portugal.

No. experienced researchers: 1
Contract duration: 12 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: Telecommunications and Multimedia Unit, INESC, Porto

4.3 Radiation resistance and reliability:

An early stage researcher:
In collaboration with a small team of specialists, assess the radiation resistance of optoelectronic components and commercial or custom built ASICs for optical data transmission. Establish irradiation methods and develop test setups. Carry out complex irradiation tests at various facilities worldwide, analyze the results and present them. Model and estimate irradiated components and system reliability through activation energy calculation and accelerated ageing tests.

No. early stage researchers: 1
Contract duration: 36 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: Advanced Reactor Instrumentation unit, SCK.CEN, the Belgian Nuclear Research Centre

Experience and knowledge

- Education .....
- Practical Experience .....
- Theoretical knowledge .....
- Ability to work in a team is a must:
- Willing to travel and communicate is essential

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- Good knowledge of English or French; basic knowledge of the other language or an undertaking to acquire it rapidly.

4.4 Optical Packaging:

An early-stage researcher:

In collaboration with a small team of specialists, characterize dense assemblies of high speed electronic and optoelectronic components for use in high energy physics experiments. Evaluate and compare properties of various commercial and custom built packages: light in- and out-coupling, high frequency electrical connectors, signal integrity, Electro Magnetic Interference (EMI), thermal conductivity etc. Establish methods and develop setups for environmental and functional tests. Carry out complex tests at various facilities worldwide, analyze the results and present them.

No. early-stage researchers: 1
Contract duration: 36 months
Application deadline: 1 June 2008
Approx. contract start: 1 October 2008
Associated partner: VTT Technical Research Center, Oulu, Finland

4. Data Acquisition for (S)LHC Experiments

Several Early Stage Researcher and Experienced Researcher with knowledge of programming and networking can be hosted in the data acquisition groups of the four LHC experiments ALICE, ATLAS, CMS, and LHCb. The LHC DAQ systems employ large (~ 5000 port) Gigabit Ethernet networks to collect data from the pre-processing modules connected to the detector. The total data rate through the systems is between 40 GByte/s (LHCb) to 100 GByte/s (ATLAS, CMS) on average with significant fluctuations. The "many-to-one" traffic patterns on the networks are such that only high-end routers are capable of handling them reliably.

The researcher's projects will involve work on one or more of the following challenges:

- *Initial ramp-up of the DAQ networks to full production size; development of techniques for profiling and monitoring the network performance and the optimization of the routed network;*

  For example, the LHCb experiment has a large (> 2000 Gigabit ports, > 45 Gigabyte/s) network for acquiring the detector data produced at the record rate of 1 MHz. The enormous packet rate requires careful optimization in collaboration with the DAQ team and the company which provides the core routing hardware. In the case of CMS, a network with Terabit/s aggregate bandwidth is constructed from two stages of switches and a layer of intermediate data concentrators for optimising traffic load. ATLAS has adopted an architecture, whereby data from the detectors are stored in 1600 buffers which are aggregated and connected through 10Gbps Ethernet links to core switches that distribute the data to over 2000 second- and third-level networked processing nodes.

- *Inclusion of fault handling in the DAQ systems in order to achieve high data taking efficiency.*

  Fault tolerance needs to be addressed at all levels, from transmission errors of event data through the switching fabric up to failures of computing nodes, and provides projects ranging from low levels, such as device drivers, up to the high level overall experiment run control

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system. These projects are more suitable for Experienced Researchers, preferably with previous experience in fault tolerance.

Optimisation of the networked data storage system in the areas of data reliability and storage virtualization.

The LHC Data Acquisition systems will record huge amounts of raw and processed data (~10 PB/year). The sustained data throughput of each experiment to the data storage system varies from 25 MB/s up to 1250 MB/s in the ALICE experiment. The storage systems give a unique chance to work with the most recent equipment and in a very demanding environment. The systems include the components of the Storage Area Network (computers, host bus adapters, storage arrays and switches), commercial software (cluster file system and home-grown software (hierarchical storage system). After becoming familiar with the storage system of the LHC experiments the second phase of the project will study possible optimisations of the storage system in the areas of performance, data reliability and storage virtualization. This phase will include the design and the development of software packages.

Studies for DAQ Upgrades for SLHC Experiments:

The LHC trigger and data acquisition systems will need significant modifications to operate at the SLHC design luminosity of up to ten times that of the LHC.

The proposed architecture for the SLHC DAQ systems is based on the expectation of scalable multi-Terabit/s networks becoming available from industry in the next decade. The work will involve tracking of networking technology in collaboration with leading industry developers, DAQ architecture feasibility studies, and construction of small demonstrator event collection systems with multi Gbps links. For example, in the case of the LHCb experiment the project will investigate the scalability and optimization issues which arise in the proposed upgrade of the LHCb DAQ at the SLHC to run at 40 MHz event rate. No full readout has ever been attempted at this rate, and therefore careful optimization of (multi) 10 Gigabit technology will be required. The work will involve a detailed feasibility study and the establishment of a technical design report for this upgrade.

No. early-stage researchers: 6
No. experienced researchers: 2
Contract duration: 36 months (ESRs); 12 months (ERs)
Application deadline: 1 June 2008 (1st tranche) and <later> (2nd tranche)
Approx. contract start: 1 October 2008 Jan 2009 ??
Associated partners: Force10 Networks Inc., San Jose, CA, USA
INFN, Laboratori Nazionale di Legnaro, Italy

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